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OF THE

SOCIETY OF TROPICAL MEDICINE AND HYGIENE

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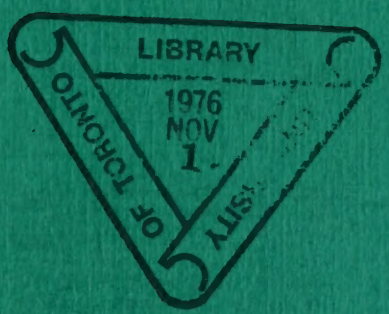

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SOCIETY OF TROPICAL MEDICINE
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VOLUME VII. Nos. 7 and 8.

Proceedings of a Meeting of the Society on Friday, June 19th, 1914.

SURGEON-GENERAL
SIR R. HAVELOCK CHARLES, G.C.V.O., I.M.S.(R.), *President*,
in the Chair.

MOSQUITO WORK IN CEYLON.

BY

MAJOR S. P. JAMES, M.D. (LOND.), D.P.H., I.M.S.

Three years ago the Government of India, having in view the risk that the opening of the Panama Canal might be followed by the introduction of yellow fever into Asia, initiated a series of enquiries and investigations with the object of devising timely measures to guard against any threatened outbreak of that disease. Their example was followed by the Governments of several British Colonies, and in January, 1913, after my return from a study of yellow fever in Central and South America, I was engaged by the Government of Ceylon to make a *Stegomyia* survey of her seaports, to study malaria in certain parts of the island, and to assist in training a body of men who would afterwards be employed as sanitary inspectors in her municipalities. Our work was an

application of the principles of what is termed the "new hygiene," of which research is the starting point, the basis, and the guide, and we are hopeful that it has justified itself by shewing that measures and arrangements based upon such research are more simple, more economical, and more effective than those recommended in the absence of the detailed knowledge which it alone can supply.

This evening I can, of course, deal with only one of the various issues with which we were occupied, and I have selected for chief notice the mosquito problem in the great seaport of Colombo, because that is a matter not only of local but of international concern.

When I arrived in Ceylon I found that some progress had already been made towards obtaining information regarding the mosquitoes of the colony, and that in Colombo three overseers and six coolies had been engaged in practical anti-mosquito work for some months. My primary duty was to study mosquitoes of the *Stegomyia* genus, which contains the species *fasciata*, the carrier of yellow fever; but as the work already begun shewed that the authorities were prepared to grant facilities for measures to control other kinds of mosquitoes, it was clearly advisable that my enquiry should be as comprehensive as possible. And this was the more desirable for the reasons that up to that time it had not been possible to deal with the subject except in a superficial way, as a relatively unimportant item in the sanitary policy of the town, and because it was felt that there was great uncertainty even of the names of the mosquitoes that were prevalent, very little information regarding their life-histories and habits, and almost none regarding the usefulness of the arrangements that had up to that time been adopted. I need scarcely remind you that although in the early years of anti-mosquito work it was usually taught that all species of mosquitoes have, in general, the same habits and mode of life, and that operations based on that assumption should be prosecuted without special enquiry, those who have devoted serious attention to the subject now hold that anti-mosquito work, upon which public money is to be expended, must be preceded and accompanied by research, with a view to ascertain at least:

1st—The names of the species that are dangerous and of those that are troublesome.

2nd—The distribution and prevalence of each of those species separately.

3rd—The life-history and habits of each.

4th—The practical methods which, in view of the knowledge collected under these headings, will be most likely to bring about a reduction of the different species.

In the absence of definite and complete information upon these subjects, it would not be possible to deal satisfactorily with the mosquito pest in Colombo, or any other large city, and for that reason they are the subjects with which we were occupied in our enquiry.

I shall take these headings in order in the following brief summary of the results of our year's work.

First, then, as to

THE NUMBER AND NAMES OF THE SPECIES.

From Colombo alone we collected no fewer than 52 different species of mosquitoes, of which 5 belong to the genus *Stegomyia*, 5 to the closely similar genus, *Ochlerotatus*, 8 to the genus *Culex*, and 8 to the genus *Anopheles*, the remainder coming in no fewer than 18 genera, whose names are rather difficult to pronounce. About 17 of the 52 species are sufficiently prevalent as to be a source of annoyance or danger to the inhabitants of Colombo, and they include 4 of the genera *Stegomyia* and *Ochlerotatus*, 6 of the genus *Culex* and 3 of the genus *Anopheles*. The names of the troublesome species in the *Stegomyia* genus are *fasciata* (the yellow fever carrier), *scutellaris*, *W. alba* and *sugens*.

Next to ascertaining the names of the dangerous and troublesome species, the subject of our second heading, namely—

PREVALENCE AND DISTRIBUTION

is of paramount importance, as being the only satisfactory basis on which to gauge the effect of measures. But you are doubtless aware that the task of making enumerations and estimations of mosquitoes is difficult. In Colombo it was especially so, because (1) the number of species to be studied was large, (2) the problem of local distribution was in general one of differences in the relative abundance, rather than in the kinds, of mosquitoes present in various areas, and (3) the various species differed widely in their habits, especially in the fact that while some were locally bred others swarmed into the town from long distances.

Of the various methods available for studying distribution and prevalence, we find that, in our experience, the systematic enumeration of adults collected either by hand catching in test tubes or in specially devised traps is the best, and, although our staff was too small for a complete enquiry of this kind, we were able to satisfy ourselves that the method is practicable, and a great advance upon the usual practice of basing estimates upon an enumeration of breeding places. We devise our traps and method of setting them in accordance with the varying habits of the different species, and I will now give you a description of one of the traps that we have found most successful. It consists of a rectangular wood framework, 5ft. long, 3ft. deep and 3ft. broad, closed with mosquito netting, one end of the trap being a door on hinges. We place these traps on the ground in the shady corner of a garden, and cover them with sacking and a thick tarpaulin, so that the interior is dark and cool. Two or three pots of plants are put inside each trap and several near the door, which is left partly open. We set the traps over night, and the next morning, about nine o'clock, we send beaters through the vegetation in the neighbourhood of the traps, and we burn straw torches in all the surrounding buildings so as to drive the mosquitoes into the open air. The result is that most of them quickly find their way into the traps, which appear to them to be very attractive and cool resting-places. After completing the disturbance of vegetation and the smoking of surrounding buildings we close the door of the trap, and collect and count the imprisoned mosquitoes.

I am now able to put before you the following tabular statement of the number of adult mosquitoes caught daily for some time in one of these traps placed in a garden in the Fort Ward of Colombo.

The trap was 5 feet long, 3 feet broad and 3 feet high, the entrance door being $2\frac{1}{2}$ feet square, and was placed near some outbuildings in a shady corner of the walled garden of Queen's House. This will give an idea of the great numbers of mosquitoes present in the area :—

TABLE I.

Date.	Number of adults caught in the trap.	Remarks.
20-11-13	200	
21-11-13	160	
22-11-13	369	
23-11-13	35	Heavy rain and wind. No sun.
24-11-13	101	
25-11-13	180	
26-11-13	250	
27-11-13	503	
28-11-13	650	
29-11-13	25	Heavy rain. No sun.
30-11-13	10	Heavy rain and wind.
1-12-13	499	
2-12-13	102	
3-12-13	304	
4-12-13	826	
5-12-13	256	
6-12-13	350	
15-12-13	204	
16-12-13	368	
17-12-13	94	
18-12-13	141	
19-12-13	200	
20-12-13	130	
In the same trap placed in the compound of the Grand Oriental Hotel the following numbers were caught :—		
7-12-13	170	
8-12-13	350	
9-12-13	581	
10-12-13	319	
11-12-13	305	
12-12-13	200	

The average of the figures is 280 per day, but you will see that on several occasions it was more than 500, and on one occasion 826. We ascertained that if we had a trap for every house garden in Colombo we could catch about the same number in each, and from the figures that we have obtained we surmise that there were $7\frac{1}{2}$ millions mosquitoes in the houses of Colombo on the 20th November, $11\frac{1}{2}$ millions on the 3rd December, and more than 30 millions a few days later.

Our trap for *Anopheles* is of a different kind. It is a movable mosquito-proof hut, each wall of which is provided with a special trap similar to those used so successfully on the Panama Canal. The traps appear to the mosquitoes to be windows through which the hut can be entered. A man sleeps in the hut, and each morning we count the mosquitoes that have been caught in the special traps.

For estimating the prevalence and distribution of *Stegomyia fasciata*, we have made extensive use of test breeding pots. In March, 1913, during our preliminary investigation by that method, we distributed over the town 168 pots of this kind, of which 14 per cent. became infected with *Stegomyia fasciata* within 48 hours and 42 per cent. within 120 hours.

As regards estimations by enumeration of breeding places, we followed the well-known plan of making monthly house to house inspections in selected areas in each ward of the town. We call the percentage of dwellings in which larvæ are found the larval index for dwellings, and we work out these figures for all mosquitoes and for *Stegomyia fasciata*. In Colombo the index for all mosquitoes is usually about 25, and for *Stegomyia fasciata* about 16. These figures, however, certainly under-estimate the real prevalence, for as regards all mosquitoes the figure refers to the locally bred species only, and as regards *fasciata* and other household and urban species it is the case that in ordinary routine house to house inspections there is no time to do more than examine the more obvious and easily accessible collections of water. For example, there is no time to make a complete examination of all the roof gutters of the houses, and no time to make a thorough search for holes in the trunks and branches of every tree in the compounds. From the following statement you will at once realise that to make

TABLE II.—BLOCK B.: FLOWER ROAD.

FIRST INVESTIGATION 7-6-13 AND FOLLOWING DATES.

Name of the House.	Potential breeding places.	Actual breeding places.
Collingwood	154	9
The Zea	744	42
Garden No. 4	201	15
,, ,, 5	327	23
House, No. 1,665	64	1
,, C.H. Pate	130	6
Garden No. 7	539	8
House No. 8	24	2
Mr. Duncan's Bungalow	265	19
Garden No. 8	892	50
House No. 9A	241	4
,, ,, 9B	434	20
Garden No. 10	526	16
,, ,, 10B	2,486	32
Clare	908	38
Areas	7,935	285

a complete examination of that kind in a fairly large house (which often contains from 20 to 40 or 50 actual breeding places) will occupy a hard worker at least three or four hours, and it is obvious that, if so much time were given to each house, a considerable staff might take two years or more to cover the town. Nevertheless it is true that unless these complete examinations are carried out an accurate measure of the prevalence of breeding places cannot be obtained. This is clearly seen in the tabular statement printed below.

TABLE III.

	Section of Fort Ward.	Section of Maradana.	Section of Slave Island.	Section of Cinnamon Gardens.
Larval index for houses as obtained by ordinary routine inspections	35·1	17·0	13·0	85·4
The same obtained by the complete investigations preparatory to anti-mosquito operations	55·5	35·5	18·0	100·0
Number of actual breeding places found in 100 houses at the ordinary routine inspections	103	38	23	394
The same found at the complete investigations	340	90	42	1833

I now pass on to our third heading, namely—

THE LIFE HISTORY AND HABITS OF THE DIFFERENT SPECIES,

but lack of time necessitates my making many omissions under this section, and in particular I shall omit all our rather numerous observations upon breeding places.

Our findings upon this and other topics of the subject shew clearly how necessary it is to study each species separately. Such a study has led us to arrange the mosquitoes of Colombo in the following broad groups based upon habits :—

A. Urban Mosquitoes—

Group 1.—The strictly household species.

Group 2.—Other urban species.

B. Rural Mosquitoes—

Group 3.—The strictly sylvan species.
Group 4.—The migrating species.
Group 5.—The species with peculiar or unexpected habits.

I will recount very briefly a few details regarding the habits of the mosquitoes in each of these groups.

Group 1.—The strictly household mosquitoes live in intimate association with man and his dwellings, and their habits have become very closely adapted to his mode of life. They may be described as being almost entirely parasitic on man alone. Their whole life is spent within or in the immediate vicinity of the house in or near which they were born, and their breeding places are of a particular kind found in the environment of human beings only. Their habits have become very fixed and definite and they can only very slightly adapt themselves to changed conditions. *Stegomyia fasciata* is the best example of this group.

Group 2.—The remaining urban mosquitoes are not strictly household insects, and not so dependent on man as those of the first group. They feed as readily upon the blood of animals and birds as upon that of man. But they pass the whole of their life in one or other section of a city or town, seldom leaving the vicinity of the place where they were born, and being able to breed in almost any kind of collection of water that may be present there. For this reason they are more difficult to reduce by antilarval measures than are the mosquitoes of the first group, whose breeding habits are highly specialised. *Culex fatigans* is the best example of this group.

Group 3.—The strictly sylvan mosquitoes spend the whole of their life in a rural environment away from human dwellings. Most of the species in this group have never acquired the habit of feeding upon human beings, but whether they have that habit or not they never, for that purpose, visit houses. There are many species of mosquitoes in this group.

Group 4.—The migratory species, while retaining their habit of breeding in swamps and natural pools at a distance from centres of population, have the habit of flying long distances into cities and towns

for the purpose of obtaining meals of blood. Some members of this group are of great interest and importance in Colombo, especially *Culex sitiens*, *Culex vishnui*, *Culex gelidus* and various anophelines. Our observations regarding them have been made chiefly in connection with the experimental anti-mosquito campaigns of which I shall speak later. One of these campaigns was carried on continuously in a section of the Fort Ward for eight months, during the last five of which we were able to keep the area almost entirely free from *Stegomyia fasciata* and *scutellaris*, *Culex fatigans* and other mosquitoes of groups 1 and 2. But during September and October migrations of great numbers of mosquitoes of group 4 into the area occurred, the sudden and quite unexpected influx being observed also by residents who had previously discarded the use of mosquito curtains. We ascertained by continuous investigation that these mosquitoes did not breed anywhere in or near our area, but that they originated from swamps, of which the nearest was nearly a mile from the locality. Towards the end of November the flight of swarms of these mosquitoes into the area became of almost nightly occurrence.

Observations similar to those that I have just recorded have been made in various countries. In India the probability that some species migrate was mentioned, and a study of the subject was commenced, in connection with the anti-malarial operations at Mian Mir in 1901-1903. In America, in the State of New Jersey, it formed in 1902-1904 the chief subject of investigation during an enquiry carried out by the officers of the State Agricultural Experiment Station. In the Panama Canal Zone this migratory habit was first placed on record in December 1912, the observations having reference to a sudden influx of *Anopheles* at Gatun, where the numbers of adult insects increased until they were very much larger than had ever occurred previously. In April, 1912, I had an opportunity of observing similar flights or migrations of mosquitoes near Guayaquil in Ecuador. It will, of course, be recalled that such observations, if they had been recorded in the early period of anti-mosquito work, would have been met with incredulity and opposition. They can be safely recorded now because it is generally realised that the best hope of success against mosquitoes lies, not in the view that all kinds have the same habits and can be dealt with in the same way, but in a full and widely disseminated knowledge of the entirely

different characters of the various species, and in an endeavour to attack them by methods based upon that information.

Group 5.—Of the group of mosquitoes with peculiar or unexpected habits I will recount briefly part of the life history of one species in order to shew how wide may be the differences between the habits of various mosquitoes. Its name is *Harpagomyia genurostris*, and it has the very curious character of living in association with ants, and of obtaining its food from them. In Colombo it breeds in the water that collects in the folded leaves of pineapple or other similar plants. After emerging from the pupal stage, the adult insect rests on a leaf or stem of the plant, gently swaying its body from side to side. When one of the small ants, which are always to be found running up and down those stems and leaves, happens to arrive in front of the mosquito, this insect suddenly thrusts its proboscis forward so that the bulbous tip is in contact with the ant's mouth. The tip is then made to work vigorously in collecting food from the mouth of the ant, and when all has been obtained the mosquito flies upwards a few inches and hovers, while the ant runs off, apparently none the worse.

I turn now to our last heading, namely :—

THE PRACTICAL METHODS WHICH WILL BE MOST LIKELY TO BRING ABOUT A REDUCTION OF THE DIFFERENT SPECIES.

I decided that, in Colombo, the various questions in connection with this subject could best be answered by experimental anti-mosquito campaigns, and to this end we initiated, during the last eight months of our work, five such campaigns in different areas of the town.

In the time at my disposal I cannot pretend to give you an adequate account of these campaigns, and you must be content with a short description of one of them, and a few general remarks about the methods employed and the results attained.

First, as to methods. As everyone knows, a municipality can set about the elimination of mosquito breeding places by one of two plans, of which the first is based upon legal powers, and the second upon voluntary action. The first is the plan that has been adopted wherever anything more than a purely temporary success against domestic

mosquitoes has been attained, and as I was anxious to ascertain by practical trial whether it could be applied in Colombo, I decided very early in our campaigns to prepare an ordinance that would be suitable for dealing with all matters that appeared to be essential for the effective control of *Stegomyia fasciata* in the town. The draft of the ordinance was submitted to the Ceylon Government in March, 1913, but as it has not yet been passed by the Legislative Council, we have not been able to test its efficacy.

In the second or voluntary plan of campaign the householders and owners of land, not being legally responsible, assist in the work only in so far as they can be brought to do so by persuasion and example. A campaign of this kind is far more arduous, far more costly, causes much more annoyance and inconvenience to householders, and meets with much more opposition than a campaign based upon legal powers. It was, however, the only method that we were able to test.

It is our rule to carry out a thorough investigation of each house and compound before beginning to take measures to abolish breeding places. After several routine tours of an area the investigation work and the measures can be carried on simultaneously, but until the area has been covered several times the attempt to combine both kinds of work leads to much confusion and an ineffective result. For ensuring continuous and thorough work in the field we relied upon frequent inspections at different times each day by myself, my two Assistants (Dr. DE SILVA and Dr. ARNDT), our Sanitary Inspector and Sub-Inspectors. For journeying from area to area we had a motor car, two motor bicycles and twelve ordinary bicycles. We found that much better results were obtained when the staff allotted to an area was frequently changed, and we usually did so once a month. In addition to the check exercised by our system of frequent inspections we found it of great advantage to institute what we call "independent investigations" in the areas. For those enquiries we employed the whole of our staff, each overseer being allotted a few houses which he examined as carefully as possible. As measures supplementary to that of the elimination of breeding places we adopted the plans of placing "trap breeding places" in the areas and of catching adults by means of the traps already mentioned. We found both methods valuable.

For testing the progress and results of our campaigns we employed the following methods:—

For Larvæ.

(1) A continuous record of the number of potential and actual breeding places found in the areas at each investigation.

(2) A periodical comparison of the number of actual breeding places found inside the area, with the number found in a similar control area just outside it.

For Adults.

(3) The opinions of members of the community resident in the area dealt with as compared with the opinions of those occupying the control area.

(4) Enumerations of adult mosquitoes by hand catching and trap catching.

(5) The use of test breeding places.

Finally, as to the results attained, I will first direct your attention to some observations about larvæ and then about adults. The statement now given is an abridged table of the records of potential and actual breeding places in the Fort area. The record begins in April and ends in December. In view of the results published for other campaigns it may seem surprising that such thorough operations as we attempted did not, after a short time, make it quite impossible to find larvæ in the area. We believe, however, that our system of frequent changes of staff and of independent investigation is a great aid to the discovery of breeding places, and that a recorded inability to find larvæ after a campaign has been in progress for even a considerable time may indicate nothing more than that, while the obvious and easily accessible breeding places have been eliminated, many others, which may be inaccessible or difficult to find, are being overlooked. You will see that the column of figures, up to the end of the sixth investigation, indicates a result that appears on paper to be highly successful, and it is probable that, if we had kept the same overseers and staff in the area continuously, it would very shortly have happened that no larvæ at all would have been found. The change of staff and the institution of independent investigations shewed, however, that those early results were somewhat inaccurate and misleading, and that in anti-larval campaigns steps have to be taken to overcome the frailty of man, as well as the wiliness of the mosquito. One of our observations resulting from the

Table VI.

Record of Potential and Actual Breeding Places.—Fort Ward.

Approximate Date.	Number of the Investigation.	Total for the Area.		Remarks.
		Potential.	Actual.	
30-4-13	1st	5,144	275	
	2nd	2,814	34	
	3rd	2,385	3	
	4th	2,159	16	
	5th	2,068	1	
	6th	2,014	4	
	Overseers	and Staff	changed.	
11-6-13	7th	6,762	35	The increase in potential breeding places is due to a different method of enumeration by the new staff.
	8th	6,907	12	
24-6-13	*9th*	*6,884*	*39*	"*Independent investigation.*"
	10th	5,512	40	
	11th	4,779	56	
	12th	—	—	
27-7-13	*13th*	*5,093*	*45*	"*Independent investigation.*"
	14th	4,744	19	
	15th	4,971	6	
	16th	4,808	5	
	17th	4,700	4	
	Overseers	and Staff	changed.	
16-8-13	*18th*	*4,724*	*14*	"*Independent investigation.*"
	19th	4,622	20	
	20th	5,041	15	
	21st	4,584	10	
	22nd	4,687	8	
18-9-13	*23rd*	*4,330*	*2*	"*Independent investigation.*"
	Overseers	and Staff	changed.	
24-9-13	24th	4,799	3	
	25th	4,495	2	
3-10-13	*26th*	*4,737*	*8*	"*Independent investigation.*"
	No Operations	done for	3 weeks.	
23-10-13	27th	4,849	92	Increase following absence of operations.
	28th	4,478	30	
	29th	4,422	20	
10-11-13	30th	4,602	9	
	31st	4,202	4	
22-11-13	*32nd*	*4,419*	*12*	"*Independent investigation.*"
	Overseers	and Staff	changed.	
28-11-13	33rd	4,492	7	During these weeks the migratory species *C. sitiens*, *C. vishnui*, etc., were attempting to breed in the area. The increase is due to those species.
	34th	4,411	12	
	35th	4,437	21	
23-12-13	36th	4,218	25	

institution of these precautions is of especial importance. It is that the elimination of breeding places which are easily accessible leads mosquitoes to discover places which are very difficult for ordinary human beings to find, and when found are very difficult to destroy. This clever change in the habits of mosquitoes greatly increases the difficulties of a campaign, and is one of the reasons why it is hardly possible, even for highly skilled workers, to exterminate mosquitoes, and why the brigades of voluntary untrained labour recommended in the popular books seldom effect a reduction in the number of adult mosquitoes, although they eliminate many of the more obvious breeding places. One method of overcoming that wily habit of mosquitoes is to employ the trap breeding places which I have already mentioned to you, and we have used that plan largely in our campaigns. The plan is due, I think, to the ingenuity of Mr. HOWLETT, the Imperial Entomologist in India, and you will at once realise that it contains the germ of a valuable idea which may lead to the working out of *constructive methods* of overcoming mosquitoes in place of the crude plan of indiscriminately destroying their breeding places which, until recently, has been the only practicable means at command.

After our operations had lasted some months it became plain that the amount of breeding that was going on in the area was very much less than at any previous time, and that it was very much less than occurred in our control area in which no operations were done. The table printed below indicates this clearly.

TABLE V.

(*A.*)—PERCENTAGE OF HOUSES IN WHICH LARVÆ WERE FOUND (LARVAL INDEX FOR HOUSES).

Date.	In the area.	Outside the area.
1st May	55·5	33·0
24th June	26·3	29·3
10th July	18·6	—
21st July	26·3	30·0
8th August	6·1	41·8
4th September	10·0	45·0
3rd October	3·7	41·8
20th November	11·1	42·3

(*B.*)—Number of Actual Breeding Places in 100 Houses.

Date.	In the area.	Outside the area.
1st May	340	—
24th June	48	90
8th August	6	112
3rd October	10	158
20th November	15	246

You will see from this and the previous table that we were very successful in extirpating breeding places from the area, but of course those results do not tell us anything of the degree to which adult mosquitoes may or may not have been reduced. On that subject our results at first were disappointing, because at the end of the first six weeks, although we had eliminated by far the greater number of the breeding places in the area, and had, every six days, regularly destroyed the larvæ in all others that we could find, it was still very easy to detect in the area the presence of many adult mosquitoes of the three species, *Stegomyia fasciata*, *Stegomyia scutellaris*, and *Culex fatigans*, against which our efforts were specially directed. It was chiefly this observation that led us to introduce the system of periodically changing the staff and of carrying out independent investigations, but nearly three months passed before a very striking reduction in the number of adults became apparent. From the middle of July, however, it became quite difficult to collect any adult specimens at all, and by this and other tests we satisfied ourselves that we had effected a great reduction in their numbers. The success became even more striking during August and September, and early in the former month I received the following letter from the A.D.C. to His Excellency the Acting Governor of Ceylon:—

"The Queen's House, Colombo,
"2nd August, 1913.

"My dear Major James,

"I promised to let you know the result of your campaign against the mosquitoes here. His Excellency asks me to tell you that as far as Queen's House itself is concerned they are now practically non-existent, and he is very pleased with the result of the experiment.

"Yours sincerely,
"P. Beattie Crozier."

Later I received letters containing similar information as regards a number of hotels and business premises in the area, and the evidence of our success is enhanced from the fact that I received at the same time some letters from hotels and buildings *outside* the area, stating that the mosquitoes in those places were as bad as ever.

In our experience the most severe test of a reduction of adult *Stegomyia fasciata* is provided by the earthenware test or trap breeding pots that I have mentioned to you, and for this reason I consider that the following tabular statement indicates that we had really been very successful in reducing that species.

TABLE VI.

Dates.	Percentage of test pots infected.
25–7–13	41·6
30–7–13	33·3
4–8–13	33·3
30–8–13	29·1
4–9–13	17·0
9–9–13	17·0
13–9–13	12·5
18–9–13	8·1
23–9–13	4·1
30–9–13	8·1
6–10–13	4·1

Taking into consideration all our tests, we consider that we have abundantly proved that, although we have been unable entirely to extirpate *Stegomyia fasciata*, *Stegomyia scutellaris*, and *Culex fatigans* from the area, we have reduced them to negligible numbers, and maintained the reduction sufficiently long to make it certain that, if the arrangements are continued, the results will be permanent.

Unfortunately I have again to refer, however, to the interesting but disquieting observations regarding the migratory species of mosquitoes whose habits I have already mentioned. In August, shortly after receiving the letters previously referred to, a migration of great numbers of those mosquitoes into the Fort Ward occurred, and was observed and reported to us by several residents; but on that occasion the unusual prevalence did not last more than a few days. On the 10th of September, we again found that many adults of *Culex sitiens*, *Culex vishnui*,

Culex gelidus, and two or three other species, were present in the area, and at intervals throughout that month and the next, similar observations were made. During those months we carried out a number of special investigations throughout our area, our control area, and the neighbourhood generally, in the hope of finding that these species were breeding, if not actually in our area, at any rate within a reasonable distance of it. We proved, however, that that was not the case. In November the matter became serious because, although we could find no specimens of *fasciata*, *scutellaris*, or *fatigans*, the abundance of adults of the migratory species became so great that, from the point of view of the lay public, our work appeared no longer to be efficacious, and we learnt that residents were obliged again to resort to the use of curtains.

I have no time to tell you of our other four campaigns, but as regards both the urban and rural mosquitoes the results were very similar to those I have described. If I were asked to sum up the results of all our campaigns very shortly, I would say that by strictly local measures we attained a marked success in reducing the mosquitoes of groups 1 and 2 (namely, the strictly household and the remaining urban species), but that the mosquitoes of group 4 (the migratory species) will continue to be troublesome in the town at certain seasons, however thoroughly measures *confined to the town itself* are carried out. The latter fact, of course, is very unfortunate, but it cannot be too strongly urged that it should not be permitted to prevent or delay—

(a) Active measures against the household and other domestic mosquitoes, of which *Stegomyia fasciata* and *Culex fatigans* are examples.

(b) Active investigation with a view especially to the discovery of new methods of attacking the species against which local anti-larval measures are ineffective.

I think I have now said enough to shew that in order to deal with the troublesome and dangerous pest of mosquitoes in our great Eastern seaports we must abandon the arrangements described in the popular books that we have doubtless read; we must give up the idea that great things can be accomplished by cheap and easy methods; we must set out on a new line. Even the single task of reducing *Stegomyia fasciata*

must be regarded, not as a trivial affair, but as a task of immense difficulty, only to be accomplished when the staff and materials provided are sufficient to enable a great, a long, a hard, and above all a scientific battle to be waged. I want those words to sink into your minds. The idea is still very prevalent that if a municipality spends even a little money upon mosquito destruction, by employing say three or four overseers to perambulate the town and destroy a few very obvious breeding places, some reduction of mosquitoes will result. Unfortunately this is by no means necessarily the case, and it is probably true that unless a municipality is prepared to undertake mosquito elimination thoroughly—to place it in fact in the forefront of their sanitary programme—their results will be about as satisfactory as if they had left the problem alone. In this matter half measures are futile. What is very desirable in large seaports and cities is the establishment of a special Anti-mosquito Department separate from, but working in conjunction with, the establishment of the Medical Officer of Health, and consisting of a properly qualified entomologist and a staff of thoroughly trained workers, provided with legal powers, and with liberal funds and materials for carrying on their work in an adequate manner and for testing its results in a scientific way. I am of opinion that the best policy for such a department to pursue would be one of investigation combined with experimental measures. Such a policy cannot be followed except under the direction of an officer who has previously received a thorough training in entomology, and is engaged to devote his whole time to the task. And I think the period has gone by when work of this kind should, as a general practice, be added to the multifarious duties of Medical Officers of Health. Instead, on the analogy that an enlightened municipality employs a trained bacteriologist, a trained chemical analyst, and at least three or four officers specially trained in different branches of engineering, it should employ a trained entomologist to deal with the highly specialised problems connected with the serious pest of mosquitoes and other disease-carrying insects.

Finally, the imperfect record that I have presented to you will, I hope, help us to realise that when the special department of which I have spoken is created, the public will have to be very patient with regard to results. They must not expect the mosquitoes to disappear (like they do in the popular books) as soon as the funds have been allotted

and the staff appointed. They may criticise the department if they like, for honest criticism is always helpful, but they must not break it up if its work appears at first to be almost fruitless of results. Instead, let us hope that they will applaud it when it is successful, console it when it fails, cheer it when it recovers, but above all let it battle on.

Discussion.

Dr. P. H. Bahr: I should like to congratulate Major James on his paper. I need hardly say that I admire him, not only as an entomologist but as a man, for I have had reason to thank him for his great assistance to me when I was groping my way amongst the mosquitoes of Ceylon. Anyone who has tried to work at these insects in the East will recognise the debt we owe Major James for his excellent work on the anopheline mosquitoes of India; let us hope he will produce a similar work on the mosquitoes of Ceylon. Before Major James arrived in Ceylon very little was known of the mosquitoes indigenous to that island; in fact, knowledge rested on collections made by Dr. Chalmers and Mr. Green, of Peradenija, but in many instances his terminology was out of date. Very great confusion existed, and no one was certain of the identity even of the anopheline carriers of malaria in the island. Now, thanks to Major James's work, the malaria carrier in Ceylon is well known, and a great deal of very valuable information has been collected with regard to sanitation in general, which not only applies to Ceylon, but to the whole of the tropical world, and I am sure we all have cause to feel very grateful to Major James for the work he has done.

The most practical part of the paper to my mind is Major James's insight into human nature. I think anybody who has worked at sanitation in the East and knows the character of the Sanitary Surveyor, will applaud his shrewdness in frequently changing the staff. I think we are all rather too apt to accept results, which, though plausible enough, are not based on a scientific basis, and probably statements of this nature, in popular works which he refers to, have kindled Major James's wrath.

Mr. E. E. AUSTEN: The thing that strikes me in particular is the thoroughly *scientific* character of Major JAMES's work, using the term "scientific" in the very best sense. At one time it appeared to be thought—I do not know whether it is so now—that to be really scientific in matters of biology, you must do something with a microtome, you must dissect and cut sections. Well, after hearing Major JAMES's account of his work in Colombo I am sure that, if that idea was present in the mind of anybody here to-night, it has been effectually banished. The account of the work we have heard this evening goes very far to support the definition of science given years ago by an eminent scientist, who said, "Science is the attempt to discover the causes of things." I think that, after hearing the paper, we shall all agree with that definition, because if Major JAMES has demonstrated anything at all, it is the utter futility of attempting to rid our seaports and centres of commerce of mosquitoes unless we really understand what and where they are, where they breed, and whence they come.

Another point to which Major JAMES draws attention is the inadequacy of amateur and partial methods. I think it is generally admitted that amateur methods are ineffective, inadequate and of no practical help, and I feel it would be admirable if, as one of the results of Major JAMES's work, an Imperial Anti-Mosquito Code could be evolved and made compulsory on municipalities and communities by law. Unless you can compel people to carry out sanitary measures you get very little done, because of the apathy with which you are always confronted.

Just one or two other points. Major JAMES spoke of trap breeding places. As he said, I think they were first suggested by Mr. HOWLETT, in India. I was particularly interested in his remarks on this subject; because I hope it may be possible to use trap breeding places of a different kind in order to bring about the local abolition of another group of disease-carrying insects, I mean the tsetse-flies. This method has not yet been tried against these insects in Tropical Africa, but, on the analogy of what has been done in India and Ceylon in the case of mosquitoes, trap breeding places, combined with the destruction of natural breeding places, would seem bound to be of assistance. If it be possible to construct artificial breeding places for tsetse-flies as well as for mosquitoes, we may be able to reduce the numbers of the two

principal Sleeping Sickness carriers, *Glossina palpalis* and *G. morsitans*, in the vicinity of settlements in Tropical Africa.

Major JAMES said nothing about measures against invading hordes of mosquitoes, which he spoke of as flying into Colombo from a mile or so away. I should like to ask him whether he made any experiments with larvæ-devouring fish, such as "millions" or "top-minnows" as used in the West Indies, or whether the supposed virtue of such fishes is merely another of the delusions due to the "popular" books referred to more than once in disparaging terms by the author of to-night's paper.

Mr. F. D. EVANS: There are several important things mentioned in this most interesting paper upon which I may comment. The most important thing, in my opinion, is the migration of certain species of mosquitoes. In the Malay States, where I have been working, we consider we have dealt with the mosquitoes as far as the breeding places of *Anopheles* in certain areas, but if we get any large hordes of Assyrians coming in to devour up the local inhabitants, we shall find the satisfactory figures which we have obtained will be considerably altered. Of course, we have always had the possibility of migration, and it seemed to me that it was not a very important thing, because, as regards malaria, it is only—at least, so I am told—the female *Anopheles* we have to fear, and, if all the water in a neighbourhood is done away with, it seems to me that we shall interfere considerably with the natural habits of the female mosquito, and it will die because it will not be able to carry on those habits. I should like to know Major JAMES's opinion on that point.

Major JAMES uses some rather fine traps. We have not got as far as that in the Malay States, although we have a medical entomologist at work on the subject, and he spends his whole time on the matter. Dr. WATSON has used a very interesting method for rapidly ascertaining what mosquitoes are found in a particular place. He made a large butterfly net, and used to drive slowly round the town about six o'clock in the evening, for about an hour or two, holding out the net. He then went back and collected his spoil. That gave him some idea of the species in the place.

There was one point Major JAMES was particular to make, and that was the necessity for really close work in connection with mosquito

destruction. One set of figures brought it out especially. He shewed, after making a preliminary survey that 394 breeding places were found, and on making a close survey he found 1,830. Now you have got to find the larger number and it is that that makes it so difficult. In the Malay States, we have been carrying out anti-malarial work principally against anopheline mosquitoes and for some years it did not prosper, because it was carried out casually. The Government decided to carry out the work more strictly, a staff was provided to devote their whole time and one district was selected to work in, and we claim to have done the work most successfully. While I am here in England, I hope to give some account of our work. I am reading a paper at the International Congress of Tropical Agriculture, on the results we have achieved, with a view of convincing the financial people there that it is very cheap to get rid of malaria. I wish to thank Major JAMES for his most interesting paper and the account he has given of the methods he has adopted in anti-mosquito work.

Dr. F. M. SANDWITH: I am very much interested, like the last speaker, in Major JAMES'S paper, and especially with his references to the dangerous adaptability of some insects, remembering always that the females "are more deadly than the males" in adapting themselves to altered conditions which man has tried to introduce. It has always seemed to me, to put it in unscientific language, that the malaria-mosquito problem will never be dealt with thoroughly until the human male becomes at least as clever as the female mosquito. Major JAMES very modestly brought the anti-mosquito work initiated by him in Ceylon up to August, 1913. I think he will not be disappointed to hear that the work which he initiated is going on to a certain extent, and that only last month, at the hottest time of the year, I and many other people in Colombo were able to sleep without an electric fan and without a mosquito net. When we tried to continue this habit in the centre of the island we thought of Major JAMES, and we had not the same blessings on our lips, for we had restless nights and woke with a rash like early small pox on our foreheads in the morning.

Major JAMES has not had time to tell us much about anti-malarial work in Ceylon. When I was travelling for a couple of weeks through the island, I could not help thinking of him and of the preventive

methods which will have to be undertaken on the estates. The total attendances in Ceylon at the various dispensaries provided by the Government and by estates are nearly two millions per annum, of which about one half are persons suffering from malaria, besides an enormous number suffering from "fever of unknown origin." Ceylon in 1912 had a death-rate of 32·7, and in 1911 it was even higher, 34·8 per thousand, and the chief cause of this high mortality is returned as malaria. To show that the Government is doing something to help anti-malarial measures, although I saw enough of them to see that their views are primitive and deal more with the individual sick than with the ninety-nine sheep in the wilderness who are not apparently sick, they distribute quinine freely, 170,000 ounces in the year. It is a fine country for those who believe in drugs and those who like to administer them. The island is full of native apothecaries and druggists, "who pour medicines of which they know little into bodies of which they know less."

Dr. C. F. HARFORD: I notice that Major JAMES has purposely abstained from saying much concerning the relationship of mosquitoes to disease. I should like, however, to ask him whether in the course of investigation he has any suggestions to make as to any further depredations which may be made on the human race by the agency of the mosquito, than those with which we are already familiar in the well-known mosquito-borne diseases, and also whether, in these various campaigns he has been carrying out, he has got any information as to the reduction of any diseases, especially as to malaria. I should also like to ask him whether the Government are taking measures for dealing with the miserable gutters, deposits of rubbish, and jungle gardens, and other breeding haunts of mosquitoes which he shewed in his pictures. The Americans have met with great success in forcing the people to deal with such nuisances, and I should like to know what the Government of Ceylon are doing in such a hopeful place as Colombo.

As to the groups of mosquitoes which he has described, I notice that he speaks of the first group as being parasitic in man, and of a fourth migratory group who do not live in the neighbourhood of human habitations, but go long distances to get their feed of blood. Can

Major JAMES tell us whether these migratory mosquitoes always return to the far off breeding places from which they have come, or whether they eventually settle down and breed in their new neighbourhood, and take on similar habits to those of Group 1? I shall be glad if he can answer these questions.

The PRESIDENT thanked Major JAMES for his paper and called on him to reply.

Major S. P. JAMES: I wish to thank our President and Fellows sincerely for their kind congratulations upon my paper. The necessity for brevity prevents me to-night from commenting upon many of the valuable observations and enquiries that have been made during the discussion; and for details upon those matters I must ask you to await the report* which I understand will be published in a few weeks. The subject of malaria in Ceylon, however, which has been introduced into the discussion by several speakers, is not dealt with in that report, so I take leave to bring to your notice that some aspects of it are described in my reports on "Malaria at the Port of Tallai Mannar" and on "The Sanitary Conditions of Jaffna and the Northern Ports," and in the valuable reports by Dr. BAHR and Dr. GUNESEKERA on "Malaria in Kurunegalle." Unfortunately we had no opportunity of studying malaria on the tea and rubber estates, where, as Dr. SANDWITH has told us, it is a chief scourge of the workers. I was greatly interested to hear from Mr. EVANS of his successful campaign against malaria in a district of the Federated Malay States. Some three years ago, in collaboration with Dr. STANTON, I examined several malarious localities in that country and came to the conclusion that the difficulties in connection with the anti-malarial problem had not, up to that time, been overcome, so the success which Mr. EVANS now reports is very noteworthy. I shall be very glad if he will inform us regarding the tests employed for measuring any reduction of anopheles mosquitoes that may have occurred, and what has been the final result of the subsoil tile drainage operations upon which a considerable sum of money was spent on some estates a few years ago. Regarding the methods of testing for a reduction

* "Report on a Mosquito Survey of Colombo and the practicability of reducing Stegomyia and some other kinds of mosquitoes in that seaport." Published at the Government Printing Office, Colombo, Ceylon.

of anopheles mosquitoes, I am strongly of opinion that the time has gone by when we should be content to decide that there has been a notable reduction if we find that there has been a statistical reduction in the amount of malaria among human beings. It was partly with the hope that a thoroughly trained entomologist would devise satisfactory methods of enumerating mosquitoes and trustworthy methods of testing the results of efforts to destroy them, that I advocated the employment of such an officer in Colombo.

In the course of his valuable remarks Mr. AUSTEN asked whether we had tried fish for destroying the larvæ of the migratory species of mosquitoes. We did not do so because (as I said in my paper) the migratory species were breeding a mile or more away from the area to which our operations were confined. But there are a good many kinds of larva-eating fish in Ceylon, and it is the case there, as in other countries, that in open collections of water, without weeds, such fish are very useful for reducing the numbers of larvæ.

In reply to Dr. HARFORD'S enquiry regarding the steps that are being taken by the Ceylon Government, I may say that the sympathetic and encouraging attitude adopted towards our experimental efforts leads me to hope that, when money and men become available, all the recommendations made in my final report will be sanctioned, the work probably being carried out in co-operation with the new Sanitary Department, which, you are doubtless aware, has been recently organised in the Colony. Some details regarding Dr. HARFORD'S second question, as to the habits of the migratory species of mosquitoes are given in my final report, and now I have time only to say that in our experience the great majority of those mosquitoes remain in the new neighbourhood only until they are ready to lay eggs. When that time comes they return to the swamps from which they originally came. They do not change themselves into domestic or household insects similar to the mosquitoes of Groups 1 and 2. In this connection I trust that my remarks upon the adaptability of some species to changed conditions have not led you to believe that mosquitoes easily change their habits or that they commonly do so. This is not the case. Their adaptability to changed conditions and environment is very limited, and some of the findings which now appear to us to be due to adaptability are better explained on the view that our previous

knowledge of habits was incomplete or inaccurate. I believe that when we know the life story of each species separately and thoroughly we shall find that it is very definite and unchangeable, and perhaps that it is as easy to determine the name of a species by observing its habits as it is to do so by studying its external anatomy and colour markings. For these reasons I have tried to emphasise in my paper that while we ought not to neglect the natural desire of the administrator and the practical sanitarian for "immediate practical results," the most urgent need at the present time is detailed investigation by specially qualified entomologists with a view to attaining full knowledge of the life story of each species. I believe that when that necessary preliminary work has been accomplished, the correct method of attacking many problems, which at present appear to be so difficult, will be plain.

Mr. F. D. EVANS: Of course Major JAMES is right. Tile drainage, or subsoil pipe drainage as I prefer to call it, has to be put down in rather a complex fashion, but by applying ourselves to the problem we have discovered how to do it well and cheaply. We have succeeded in draining the most precipitous ravines in the Malay States, at a low cost, and in a permanent manner. There are a number of men carrying out similar work now, both on behalf of Government and private authorities. Formerly, there were many failures, and large sums of money spent were lost or misapplied in pipe drainage.

I am afraid we never went in for measuring mosquitoes, as no records were in existence, which would make present records of much value. Sickness records do exist however. Perhaps it may be interesting to know that in Kuala Lumpur, during the five years 1907 to 1911, the death rate, with a population of over 50,000 inhabitants, from malaria fever averaged 9·56 per 1,000, and we reduced that until in 1912 we got the rate down to 5·6, and last year to 4·2, and it is still falling. Malaria was very bad there. There is a police depôt in Kuala Lumpur, where Indian recruits are trained for a few months before being sent to the force. They stay for a few months and then go out again, so they form an admirable population for the spread of malaria. There are always a number of Malays there too. In 1910, the monthly percentage ill with malaria was 32, in 1911 it was 57, and in 1912, when the work began to be effective, it went to 27 per cent., and last year it was 11 per cent.

EPIDEMIC MALARIA AND CONSTRUCTION WORKS.

By A. G. H. SMART, M.B., D.T.M. & H.,

Assistant Health Officer, Government Service, Singapore.

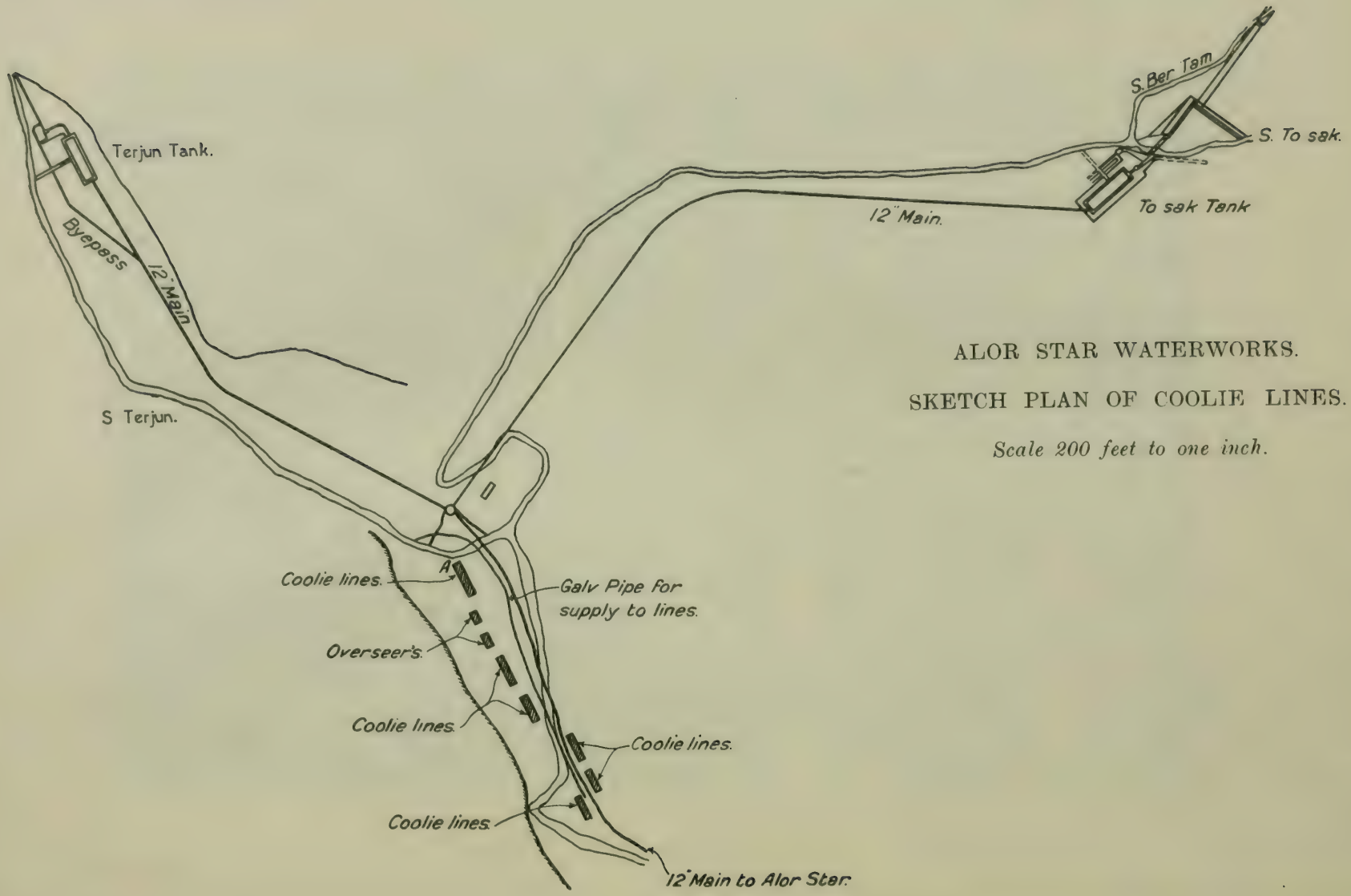
Received September, 1914.

While I was in Kedah, during the early part of this year, the State had under construction a water scheme, by which certain streams at an elevation of about three hundred feet were being tapped, and a service line was being brought down to Alor Star, the capital, a distance from the head works by road of about twenty miles.

The plan attached shews the different streams, viz. :—the Sungei Terjun and the Sungei Bertam, which united on a level with the coolie line marked "A," to form the Sungei Wang. There were two large settling tanks nearly completed, each with a capacity of four hundred thousand gallons, and a large pipe took the water from each, these pipes joining practically where the streams met to form the main going down to Alor Star.

The Terjun is the more important of the two streams from the point of view of these notes. It followed a fairly direct course through a rocky channel of quartzite formation, with steep hill slopes covered with jungle coming down on either side.

Construction work commenced in May, 1913, and a labour force was brought to the site at the head of the Sungei Wang. In the beginning the health was good, and on the 28th June, out of one hundred coolies, eleven were unfit for work, of whom five had malaria, probably infected before arrival. On July 11th, the health was reported not so good, with an undue percentage of sick. On the 30th of September, the labour force numbered two hundred and eighty coolies, and the percentage of sick was only three and a half, not all malaria, there being a certain amount of ankylostomiasis present. All the coolies were supplied with mosquito nets during September. On the 7th of November, out of three hundred and fifty coolies, only seven were unfit for work, and of these five had malaria; but on the 30th of December, the State Surgeon reported on his visit that the health was "nearly as bad as possible." Out of a total of three hundred coolies, only half this number could turn out to work, practically all the sickness being due to malaria. In



ALOR STAR WATERWORKS.

SKETCH PLAN OF COOLIE LINES.

Scale 200 feet to one inch.

addition, four cases of cholera occurred during this month. On the 16th of January of this year, out of the two hundred and eighty coolies examined, ninety had fever; in one Tamil bangsal fifty out of ninety had a temperature above normal. On the 21st of January, forty cases of malaria from these coolies were admitted to the General Hospital at Alor Star.

The following shews the monthly incidence of malarial admissions into Alor Hospital :—

1913—May	... ...	0
June	... ...	0
July	... ...	5
August	... ...	0
September	... ...	0
October	... ...	2
November	... ...	0
December	... ...	3
1914—January	... ...	61
February	... ...	18
March	... ...	18

The different infections seen were as follows :—

Benign Tertian	... ...	48 cases.
Subtertian	... ...	34 „
Quartan	... ...	2 „
Type not diagnosed	... ...	24 „

A considerable number had mixed infections, but what percentage was not recorded.

The following shews the monthly rainfall at Alor Star, and Tanjong Pau, and Sungei Wang respectively :—

1913.	Inches.	Inches.	Inches.
May	14·33 ...	10·08 ...	—
June	12·63 ...	11·08 ...	—
July	8·19 ...	7·05 ...	7·12
August	6·64 ...	8·09 ...	6·88
September ...	12·67 ...	10·56 ...	11·78
October	11·19 ...	13·70 ...	15·90
November ...	8·41 ...	8·08 ...	10·64
December ...	6·25 ...	5·42 ...	7·63

1914.						
January	...	0·18	...	0·19	...	1·15
February	...	0·30	...	1·07	...	1·40
March ...	...	1·85	...	2·59	...	0·05

Alor Star is about sixteen miles distant in a direct line from the head works, and Tanjong Pau six miles.

On my first visit to the head works on the 28th January, 1914, there were six coolie lines situated on each side of the river, as shewn in the attached plan. Following the line of the river, the bangsal marked "A," was about 500 yards from the dam, where the river was diverted into a large concrete settling tank. The course of the stream had not been interfered with, but the water was very low, while there were many side-pools forming potential and actual mosquito breeding places, especially in the stretch of river between the dam and the coolie line marked "A." Towards the end of December, several cases of cholera had occurred amongst the coolies, so, in order to obtain a safe supply of drinking water, the river was tapped well above the coolie lines, and water brought down in a two-inch service pipe, with stand pipes attached at intervals. In the stretch of river from the dam down to the coolie lines, the following larvæ were found at this visit :—

Anopheles leucosphyrus (Dönitz), in a pool at the edge of the stream.
Anopheles kochi, in a stagnant pool at the edge of the stream.
Anopheles sinensis, in an algæ covered pool.
Anopheles maculatus, at the edge of the running stream.
Anopheles karwari, at the edge of the running stream.
Uranotænia campestris, associated with *Anopheles maculatus*.

In the Sungei Bertam, within a short distance of the coolie lines were found the larvæ of *A. karwari*.

The small service pipe ran past and close to the coolie lines as shewn in the plan. It was joined up in short lengths and some of these joints leaked, small pools being formed at such sites. The larvæ of *A. maculatus* were obtained from these pools in large numbers. Pools were also produced at the different stand-pipes where the coolies drew off their water supply, such being contaminated with organic refuse, washings from cooking utensils, etc. No anopheline larvæ were found there. For several hundred yards below the level of the coolie lines the stream was also examined for anopheline larvæ, with a negative result. The

larvæ were identified by their own special characters; in a number, identification was confirmed by the respective imagines which hatched out, including that of *A. leucosphyrus*. The specimens of the latter found on this visit were taken from a pool in running water at a site just above the dam. The larvæ of *U. campestris* are commonly associated with those of *A. maculatus* and *A. karwari*, and Dr. FINLAYSON, of Singapore, has pointed out previously the significance of this, namely, that where such larvæ are found, although the larvæ of either of the anophelines may not be caught at any particular time, such a site requires to be carefully watched. The larvæ of *U. campestris* is rather slender, with a light brown body and a small black bead-like head, and is readily recognised with the naked eye, a point which increases the practical value of this observation.

The pools at the leaking joints of the small service pipe were easily dealt with, but conditions similar to those described above, were found prevailing in the stream on three subsequent visits. On my fifth visit, when I was accompanied by Dr. STANTON, we found that the stream had been cut off from the dam, and diverted into the tank mentioned above, and that although a certain amount of overflow from the tank was returning over the spillway into the original bed, the latter for a long stretch below the dam was nothing but a series of shallow pools containing decomposing vegetation, floating algæ forming a dense scum over the surface of the pool. Only the larvæ of *Culex ager* (GILES) were found in these pools, in contrast to the larvæ obtained from the same site before the stream had been cut off; in the stream just above the dam were obtained in numbers the larvæ of either *A. maculatus* or *A. karwari*. In a small jungle pool, fed by a spring, we obtained *A. maculatus* (in numbers), *U. campestris*, *A. leucosphyrus* (one male bred out later), *Lophoceratomyia barkeri* (one male and one female hatched out), and *Culex concolor*.

REMARKS.

STANTON[1] states that *A. leucosphyrus* is met with infrequently in the Malay Peninsula, and THEOBALD[2] does not include the Malay Peninsula as a habitat. JAMES and LISTON[3] mention that they have not seen a specimen for some years in India. DANIELS[4] writing on the breeding grounds of *Culicidæ*, states that the mosquito is found in cut bamboos,

but is found more commonly in other places. LEICESTER[5] found it in jungle streams, but also described it from "a large series bred from larvæ, taken from open bamboos and pools in jungle," and Colonel ALCOCK,[6] writing in the *Journal of the London School of Tropical Medicine*, gives as the habitat of this mosquito, India, Ceylon, and Sumatra only.

The conditions found shewed clearly how particular *A. maculatus* and *A. karwari* larvæ are as to their breeding places. As pointed out above, no such larvæ were found at any site where the water had become contaminated, and yet they could be obtained in numbers in identically similar sites where the water had remained pure perhaps a few yards away from a contaminated pool.

This is well brought out in the case of the small pools at the leaky joints in the service-pipe to the coolie lines, one pool swarming with these larvæ and the next being left severely alone. This is a common experience with these larvæ.

In one instance these were found in a small valley, with rather steep sides, below a Chinese graveyard in Singapore. There were a few squatters' houses at the head of this valley, and these people had tapped some springs at their houses to form wells. Dr. FINLAYSON went over this site last September, and the only anopheline larvæ then found were those of *A. sinensis* breeding in some duck-ponds. No anopheline larvæ were found at this time in the streams formed by the overflow from the wells referred to above, nor on a subsequent inspection while the squatters were living in the valley. But these squatters were turned out about the end of last year and the valley became uninhabited. In May, 1914, Dr. FINLAYSON recovered from this site larvæ of *A. maculatus* associated with those of *U. campestris*.

Reverting to the Sungei Wang conditions, it was also interesting to find *A. maculatus* breeding in the pools referred to, where the pipes leaked, shewing, as it did, that the water coming through had not become altered in any way from the raw river water. A chemical analysis of the water from the Sungei Terjun is shewn as below :—

Colour in 2ft. tube	...	...	clear, white.
Taste ...	...	...	nil.
Smell ...	...	...	nil.
Chlorine	...	...	0·4.
Total solids	...	...	5·0.

Oxygen consumed by organic matter in four hours	0·075 per 100,000 parts.
Free ammonia	trace.
Albuminoid ammonia	0·002.
Ammonia from nitrates	0·010.
Ammonia from nitrites	nil.

With reduction in the number of breeding places, as had occurred during my later visits, it is worth noting how certain remaining sites, previously only scantily occupied, became almost overcrowded, and larvæ, mutually uncongenial under more favourable conditions, became associated in very circumscribed sites. This was seen in the conditions found in a small jungle pool, referred to above, where *A. maculatus*, *A. leucosphyrus*, *U. campestris* and *L. barkeri* were found together with, in addition, the larvæ of *C. concolor*, which latter readily devour smaller larvæ, and would be the natural enemy of such.

The Sungei Terjun became very low in December, and this fall must have taken place about the beginning of the month in order to fit in with the cycle started, which would produce such a large amount of malaria among the coolies towards the end of the month and in the first half of January. It is difficult to attribute this reduction in the volume of the stream to natural conditions entirely, although later this would be justified. The rainfall at the head works in December stopped on the 24th of the month, and the total for the succeeding three months, as can be seen from the table, only amounted to 2·60 inches.

The catchment area for the Sungei Terjun had not been wholly surveyed when I was in Kedah, but the rainfall in this area would not be markedly different from that at the head works, and the latter amounted to 7·63 inches for December up to the 24th.

It is worth noting, however, that the mean minimum temperature for December, viz., 78·61, was 4·65 degrees above the average of the other eleven months from May, 1913, to April, 1914. It is likely that a constantly high temperature has a marked effect in hastening the development of the malaria parasite in the mosquito, and is also favourable to the increase of the parasite in men.

By the end of March the head works had been completed and the labour force disbanded; but had the drought not broken by the end of March, as it did, and construction not been completed, work could

only have been carried on under very trying conditions, and very little could have been done to improve the unhealthy condition of the place in so far as the Sungei Terjun was concerned. WILSON,[7] in a recent article on the suppression of mosquito breeding places, dealt with this type of breeding ground. He mentioned that the "hollows formed by the action of running water and stones on the surface of rocks in river beds form ideal breeding grounds for mosquitoes," and says that the water-holding capacity of such should be destroyed in malaria infected areas, this being accomplished either by filling in or by blasting.

In the case of the Sungei Terjun such measures, from the wide, irregular and ill-defined nature of the channel, would not have been effective or practicable. The anopheline larvæ found were breeding, not only in pools hollowed out of rock but in the edge of the running stream itself for a long stretch above and below the dam, wherever a few dead leaves, stones or other débris afforded even the slightest amount of shelter.

I am indebted to Dr. FINLAYSON, Government Pathologist, Singapore; Dr. STANTON, of the Institute for Medical Research, Kuala Lumpur; Dr. HOOPS, State Surgeon, Kedah; and Mr. GORMAN, State Engineer, Kedah, for much assistance and information.

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AMERICAN FORESTAL LEISHMANIASIS.

By J. W. LINDSAY, M.B.

I have been interested in reading in the January number of the TRANSACTIONS the remarks on the various Leishmaniases by Dr. WENYON and others present at the December meeting.

As I have been resident now for fourteen years in the northern province of Paraguay, and in the heart of the district where Leishmaniasis Forestal Americana, or Buba, has for many years been prevalent, I have thought it might be of interest to you to read or to publish something from the actual spot, and so to give you some idea of the present position up to date of the investigations on the subject in this country.

First of all I refer to the article on "Buba in Paraguay: Leishmaniasis Americana," by Dr. L. E. MIGONE, of Asuncion, Paraguay, originally published in the *Bulletin de la Société de Pathologie Exotique* of Paris, in March, 1913, and reprinted in the January (1914) number of the *Revista Médica* of Asuncion.

In the March (1914) number of the *Revista Médica* (Asuncion), Dr. MIGONE continues his studies of Leishmaniasis Forestal Americana in an article in which he criticises the views of BRUMPT and PEDROSO of Sao Palilo (Brazil) as published by them in the *Bulletin de la Société Pathologie Exotique* (December, 1913).

Without making further reference to these articles, I wish to say that so far as clinical experience of the disease goes, I entirely concur with Dr. MIGONE'S views, but having had no leisure or facilities for micro-biological work, I do not claim to be able to pronounce any opinion on the protozoology of the disease.

Referring to Dr. WENYON'S article in the TRANSACTIONS—

(1) I first of all note his mention of the case of "an Englishman who had a sore on the margin of the ear, which had been contracted apparently in South America." The most common sites for the initial ulcer or sore are the ankles and wrists or hands. I have seen various cases in which the initial lesion was on the tip of the ear; in two cases the ulcer had eaten away the upper half of the external ear.

I have seen a case in which the ulcer was on the upper frontal region, just reaching to the hairy scalp. I have seen many cases in which the typical ulcers were in the middle of the back, or at either side, just above where the men wear their belts. I have seen the ulcers at the same level on the abdominal wall in front and at the sides. The native lumbermen and maté gatherers always work stripped to the waist, their only clothing being cotton or dungaree pants down to the knees.

(2) Dr. WENYON discusses the question as to whether the infection is of a general nature or not. Dr. MIGONE, who has worked incessantly on the subject, has not been able to find leishmania in the general circulation, though they are to be found in the lymphatics and lymphatic glands draining the ulcerated portion of skin. Many patients have been able to tell me the exact date of inoculation when they were bitten by the insect, the date of the appearance of the papule and the pustule, and the exact time required for the development of the ulcer. One man sitting outside his hut in the evening was bitten on the hand by a simulium. He saw the insect, he felt the itching and scratched. In a day or two there was a reddish papule ; in two or three days more it was a pustule, and now after six months the ulcer is the size of a crown piece. Most of the patients can give some definite date of inoculation, and when they come to one for treatment after the development of the ulcer, every one of them has the same dread, " I came as soon as I could possibly get away, so that this ulcer may not ascend to my nose." The natives all regard it as a general affection, and that is why it was for so long mistaken for syphilis. How is it that six months or a year after the initial sore has cicatrized, the disease " ascends to the nose " ?

Of course, there may be many cases of buba ulcer that cure spontaneously and no nasal or oro-pharyngeal lesion appears. On the other hand, neither Dr. MIGONE nor myself, who have treated hundreds of cases, ever saw a single case of naso-oro-pharyngeal buba that had not a history of residence in infected districts, inoculation at a definite date, and the characteristic cicatrix of a buba ulcer of earlier date than the nasal lesion.

Surely the history of buba cases points to its becoming a general infection on the disappearance of the initial ulcer, just as happens in syphilis.

During the last ten years I have had cases under observation in

which the initial ulcers were completely destroyed by the thermocautery, and in which no secondary naso-pharyngeal lesions have since appeared.

In contrast to these are the unhappy victims who come in the later stages of the diseases, and tell how it had been impossible for them to get proper treatment for their leg ulcers.

According to Dr. MIGONE, the leishmania found in the initial ulcer is identically the same as that found in the secondary naso-pharyngeal lesions. The leishmania, according to Dr. MIGONE, are not found in the blood of the general circulation, either during the primary ulcerous stage or in the quiescent non-lesion stage, or in the final naso-pharyngeal stage. Where are the leishmania during the latent or quiescent stage? That the naso-pharyngeal lesions are not due to a fresh infection is proved by the fact that these symptoms appear long after the men have left the infected area.

(3) In the discussion on *Leishmania tropica* in the TRANSACTIONS, Dr. D. E. ANDERSON says: "In Brazil, where ulcerating sores of mouth and nose exist, the *Leishmania tropica* has been seen as also in the oriental sore—the *former might be the consequence of the latter.*" This opinion is most certainly confirmed by all clinical experience in this country where the disease abounds and exactly concurs with the popular belief.

(4) Dr. ANDERSON makes another suggestion: "Could oriental sore also, and even kala-azar, be traced to a sand-fly?"

This question leads me to consider the whole matter of the transmission of the disease.

Eleven years ago work was started in the virgin forest some thirty miles from here. A lumber establishment, with sawmill, etc., was built. The first workers consisted of the overseer and forty peones, or native workmen of Spanish-Indian extraction. Among the forty peones was one man who had come from lumber works some fifty miles to the north. He had a buba ulcer of the leg. All the other peones and the overseer were healthy men. Within the year all the other men and the overseer contracted buba ulcers, and of the whole forty-one affected persons all except one have since developed naso-pharyngeal lesions. The overseer treated the ulcers with copper sulphate, but the final result, as you see, was the same as if there had been no treatment. How was the infection conveyed in this instance?

From the pueblo of San José there went one December about a hundred youths and men to work in the Yerbales, or Maté forests—up till the present yerba-maté is mostly collected in the virgin forests—on their return home to their village in August, after the season's work, forty of them were found to have bad buba sores on different parts of the body.

Both in the lumber-works and in the yerbales the peones pass weeks and months right in the heart of the forest sleeping under rough shelters, wherever their work leads them, and thus they are constantly moving.

What is the current belief among the peones as to the transmission of buba ulcers? In nearly every case the patient will blame the bite of some insect. The peones of the Yerbales are almost unanimous in blaming both ticks and flies. The tick found to be adhered to the skin when the peon awakes in the morning, which he tries to remove, and as the result of whose invasion a buba ulcer develops, is nearly always the *Yatebu vacapi* or *Amblyomma striatum*.

Other patients will tell you that in the early morning or in the afternoon they have been bitten by "mbariguies." The bite itches horribly and the victim scratches frantically, a papule appears and the peon has not the slightest hesitation in telling you that his buba ulcer began just then. The "mbariguies" are simulidæ.

Where do the amblyomma and the simulium get the infection from? The peones are ready with their answer. They say the natural host of the buba virus is the rattlesnake! When you find a rattlesnake lying coiled up in the forest you will always find a cloud of simulidæ hovering over it. If you kill the rattlesnake and examine it, you will find *Amblyomma striatum* adhered to it in many places. The peones are quite positive in their opinion that the simulidæ and the amblyomma transfer the snake-poison to human beings. And it is for that reason, and not wholly because of the discomfort of the fly-bites, that the peones anoint their arms and legs with fowls' fat in order to keep the simulidæ at bay.

There may be something, then, in the suggestion that oriental sore or buba ulcer may be traced to a sand-fly. But what about the protozoa in the rattlesnake?

From what I have written it will be seen that we are led to certain definite conclusions. Now that the disease has come to be differentiated

from syphilis, etc., the diagnosis is nearly always extremely easy clinically. MIGONE has proved the existence of *leishmania in the initial ulcers and in the naso-pharyngeal lesions.* We find that cases presenting the latter symptoms always shew cicatrices of primary ulcers. Therefore, we conclude that the *naso-pharyngeal lesions appear in consequence of the original primary sore.* And from this, of course, we must admit that buba is quite as much a *general disease* as is syphilis. Again, it is seen that buba is very distinctly a regional disease—it can only be contracted in certain districts.

From this, of course, we conclude that only in these districts do we find the special combination of circumstances or agents necessary for the origination *de novo,* or the transmission of the disease to human beings. It will remain with the entomologists to prove what rôle is played by amblyomma or simulidæ, and perhaps with other investigators to find what part is taken by vertebrates, mammals, or reptiles, as the hosts of the leishmania responsible for the disease.

LIBRARY NOTES.

Under this heading we propose to review recently published works sent us for that purpose, and a short notice of any other works presented to the library.

Reviews.

Tropical Diseases. Sir Patrick Manson, G.C.M.G., M.D. Fifth Edition. Revised throughout and Enlarged. Cassell & Co., Ltd., London. Price 12s. 6d. net.

The issue of the fifth edition of Manson's *Tropical Diseases* is most welcome, not only because of its intrinsic worth but because it is a sign that the writer, who is withdrawn from close personal touch with his old colleagues and with those who delighted to listen to his words of wisdom on tropical problems, still retains his interest in the progress of Tropical Medicine. The preface to the first edition is still retained, though the character of the work as there set forth has undergone a great change. Whatever may have been the intention of the author at the outset, and whatever may be the precise meaning of the term "manual," it is certain that it has for a long time been regarded by students as the leading work on tropical diseases. The new edition has 937 pages as compared with 876 in the preceding one, and this increase is due to additions made to our knowledge in the interim. It is interesting to note changes in nomenclature. The headings, Kala-Azar, Oriental Sore and Ponos, are all included under Leishmaniasis. Malta Fever becomes Undulant Fever, whilst new headings appear, such as Phlebotomus Fever and Rat-Bite Disease. It is perhaps a pity that, having introduced a new chapter for Phlebotomos Fever, it should be necessary to refer the reader to another page for the symptoms under the heading, Three Days' Fever. In a note on the pathology of this disease an interesting suggestion is made as to its possible connection with dengue and yellow fever, which should not be forgotten. It is somewhat surprising to find no reference to the important statements made by the late Sir Rubert Boyce, as to possible confusion between yellow fever and the very indefinite class of cases which have been variously described under the

title, Bilious Remittent Fever. This term and also that of Typho-Malarial Fever have given rise to much confusion both in diagnosis and treatment, and the time appears to have come for them to disappear from a modern text-book. It is worthy also of consideration whether the classification of disease which is still adopted in this edition is really satisfactory, and whether an etiological method might not be preferable. Leishmaniasis for instance is found under the head of fevers, which is no doubt appropriate if we think only of kala-azar, but when this heading also includes the various forms of superficial lesions which are connected with the presence of Leishman bodies the classification is hardly suitable. These however are comparatively minor points which are not easy to alter in a new edition of an existing work. On the whole, recent observations on the most important diseases have been very skilfully incorporated into the text, *e.g.*, those concerning Leishmaniasis are specially to be noted. After reviewing various opinions as to the character and effects of *Trypanosoma rhodesiense*, the following significent sentence appears:—"The destruction or driving back of the large game in morsitans countries seems to be the only measure likely to avert what might otherwise prove to be an immense calamity." The latest theories concerning pellagra and beri-beri are carefully noted, whilst among recent therapeutic measures ROGERS' treatment of amœbic dysentery by emetine is quoted with cordial approval. MANSON'S *Tropical Diseases* is a wonderful compendium of information and is thoroughly up to date.

Practical Tropical Sanitation: a Manual for Sanitary Inspectors and others interested in the Prevention of Disease in Tropical and Sub-Tropical Countries. By W. ALEX. MUIRHEAD, Staff-Sergeant R.A.M.C., Assistant Instructor at the School of Army Sanitation, Aldershot. Illustrated. John Murray, Albemarle Street, W. 1914. 10s. 6d. net,

The fact that tropical sanitation is a natural outcome of tropical research makes it necessary that those who are to be engaged as sanitary officials, but who are not trained medical workers, should have before them a careful statement of the main facts concerning tropical disease and the practical measures which can be adopted for the prevention of disease in hot climates. The book before us seems to be admirably

adapted for this purpose. It is clearly written and well illustrated, and is a thoroughly practical handbook. The book is most appropriately dedicated to Sir RONALD ROSS, and it must be a satisfaction to one who has been a foremost pioneer in the work of tropical sanitation to see so good an exposition of sound views on this important subject.

Some Minute Animal Parasites. By H. B. FANTHAM, D.Sc., B.A., F.Z.S., Lecturer in Parasitology, Liverpool School of Tropical Medicine; and ANNIE PORTER, D.Sc. (Lond.), F.L.S. With Frontispiece and Fifty-six Text Figures. Methuen & Co., Ltd., 36, Essex Street, W.C.

We welcome the issue of this volume, which states the main facts of tropical parasitology in a way which would be of interest to the ordinary reader. The book is intended for science students who are unable to make a full study of the literature of tropical disease. The names of its authors are sufficient indication that the book is in accord with modern knowledge, and it is a most readable volume. We cordially commend it to those for whom it is intended.

PRESENTED TO THE LIBRARY.

Dysenteries: Their Differentiation and Treatment. By LEONARD ROGERS, M.D., etc. Henry Frowde and Hodder and Stoughton. 10s. 6d. net.

This important volume is a valuable addition to our library. Sir LEONARD ROGERS has rendered many services to the cause of Tropical Medicine, but his introduction of the use of emetine in cases of amœbic dysentery, as described in this volume, is perhaps the greatest of all. We hope that he may be as successful in the methods of treatment of other tropical bowel complaints as he has been in dealing with dysentery and cholera.

NOTICE OF MEETING.

SESSION 1914-15.

The opening meeting of the New Session will be held at 11, Chandos Street, Cavendish Square, at 8.30 p.m., on Friday, October 16th, when a paper will be read by Surgeon-General Sir DAVID BRUCE, K.C.B., R.A.M.C., on "Classification of the African Trypanosomes Pathogenic to Man and Domestic Animals."

ELECTION OF FELLOWS.

The following were duly elected Fellows of the Society :—

WILLIAM W. CADBURY, M.D., Canton.
HENRY R. CARTER, Senr., M.D., Baltimore.
FRANK D. EVANS, A.M.I.C.E., Kuala Lumpur.
Major A. N. FLEMING, M.B., I.M.S., Bombay.
ERNEST H. GRIFFIN, M.A., D.T.M. and H., Mexico.
Major S. P. JAMES, M.D., I.M.S., Simla.
N. MACLEAN LEYS, M.B., Nyasaland.
KATE W. MCBURNEY, M.D., South China.

EXCHANGES.

Anales de la Academia de Ciencias Medicas Fisicas y Naturales de la Habana.

Annali di Medicina Navale e Coloniale.

Archives de l'Institut Pasteur Tunis.

Arquivos do Instituto Bacteriologico Camara Pestana.

Bulletin Public Health and Marine Hospital Service of the U.S.

Bulletin of the Tropical Diseases Bureau.

Bulletin de la Société de Pathologie Exotique.

Bulletin de la Société Portuguaise des Sciences Naturelles.

Bulletin de l'Academie Royale de Médecine de Belgique.

het Geneeskundig tydschrift voor Nederlandsch-Indie.

Johns Hopkins Hospital Bulletin.

Journal of Tropical Medicine and Hygiene.

Journal of Tropical Veterinary Science.

L'Enseignement Medico Mutuel Internationale.

Memorias do Instituto Oswaldo Cruz.

Philippine Journal of Science.

Revue de Médecine et d'Hygiene Tropicales.

Sanidad y Beneficencia.

The American Journal of Tropical Diseases and Preventive Medicine.

Veterinary News.

Yellow Fever Bureau Bulletin.

NOTE.—The above publications lie in the Society's room at 11, Chandos Street, W., and are at the disposal of Fellows.

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